**BTnodes – Bluetooth Smart Nodes**

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**IP9 Prototyping Platform Components**

- **Maxi - PC Platform**
  - Laptop
  - Wireless LAN 802.11a/b
  - Bluetooth
  - Full native development and operating system
  - Full Java IDE/JRE

- **Mini - PDA Platform**
  - iPQ + CF Card = 15x10x2
  - Ethernet
  - Bluetooth
  - Cross development and operating system support
  - Simple Java JRE

- **Micro - Embedded Platform**
  - µC + BT Module = 6x4x0.5

**Platform Comparison: Size [cm³]**

<table>
<thead>
<tr>
<th>Platform</th>
<th>Size [cm³]</th>
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<tbody>
<tr>
<td>Maxi - PC Platform</td>
<td>3200 × 3200</td>
</tr>
<tr>
<td>Mini - PDA Platform</td>
<td>2000 × 512 × 40 = 108</td>
</tr>
<tr>
<td>Micro - Embedded Platform</td>
<td>8 × 0.064 × 0.128 × 0.8</td>
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**BTnode – The Embedded Micro Platform in Detail**

Autonomous wireless communication and computing platform based on Bluetooth radio module and a microcontroller.

- Small form factor, low component count
- Standardized wireless interface
- Flexible and cost effective deployment of large quantities of networking nodes

**Hardware Features**

- Atmel 128 MCU (max. 8 MHz – 8 MIPS)
- 128 k Flash, 64 k RAM, 4 k EEPROM
- Generic sensor interfaces
- UART and GC data interface
- Power and Frequency management
- Bluetooth communication
- Integrated antenna

**Power Consumption [mW]**

<table>
<thead>
<tr>
<th></th>
<th>max</th>
<th>typ</th>
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<tbody>
<tr>
<td>Bluetooth</td>
<td>250</td>
<td>160</td>
</tr>
<tr>
<td>Connected/CPUs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CPU Idle/CPUs</td>
<td>95</td>
<td>67</td>
</tr>
<tr>
<td>Off/CPUs Sleep</td>
<td>6</td>
<td>&lt;0.5</td>
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**Testbed Deployment**

- Current deployment ~200 units
- Unit cost € 110

**BTnode Cooperation**

The BTnodes have been developed and distributed to researchers in cooperation with the Smart Its Project, that is part of the EU Disappearing Computer Initiative.

**Event Driven System Software**

**System Software Overview**

Lightweight OS made up of drivers that are interrupt driven and a dispatcher for scheduling application and driver tasks. Similar but simpler than TinyOS [Culler et. al.].

**Software Features**

- Low level drivers and libraries for peripherals and interfaces
- Event driven application model facilitates coarse grained cooperative multithreading
- 30 k codesize in ROM, 1-2k in RAM, with 128 byte UART buffers for communication

**Software Architecture**

- Application
  - Task 1
  - Task 2
  - Task 3
  - Task 4

**Hardware**

- Driver
  - BTnode

**Communication**

- Bluetooth Stack
  - ATmega128L
  - Microcontroller

**Development Environment**

- GNU GCC crosscompiler development environment
- In system programmable (a remote update function is under development)

**Bluetooth Protocol Stack**

- Baseband processing on subsystem
- Reduced host controller stack
- Elementary functions of link layer
- Selection of Bluetooth profiles

**Communication with Bluetooth enabled Appliances: GSM Mobile Phones**

The BTnodes can communicate with other Bluetooth enabled devices using standard Bluetooth profiles for SMS (AT commands) and object push (OBEX).

**Example Product Monitoring**

In our demo example we can be alerted of sensor events such as shock or heat via SMS from a BTnode that acts as a smart tag. Vice versa an application can inquire a BTnode enabled ‘smart object’ for data and status.

**Example Remote Topology Discovery**

**Some Demo Applications**

**IP9 Communicating Embedded Systems**